

EXOCOETIDAE (BELONIFORMES) OFF NORTH-EASTERN BRAZIL

by

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ABSTRACT. - From March 1994 to May 1998, in the area between 2°N and 14°S, and from 28°W to 41°W, 1652 Exocoetidae were collected by research vessels and artisanal fishery boats, as part of the REVIZEE Project (Brazilian Economic Exclusive Zone Assessment Program). Eleven species were identified: *Cypselurus comatus*, *C. cyanopterus*, *C. exiliens*, *C. heterurus*, *C. melanurus*, *Exocoetus volitans*, *Hirundichthys affinis*, *H. speculiger*, *Oxyporhamphus micropterus similis*, *Parexocoetus brachypterus* and *Prognichthys gibbifrons*. The species *C. cyanopterus* and *H. affinis* are abundant in the region, the former in the Archipelago of São Pedro e São Paulo, used as tuna bait and the latter is the main product of the artisanal fishery in the State of Rio Grande do Norte. As a potential resource and an important part of the epipelagic food chain, they were considered target species in the scope of REVIZEE Project.

RÉSUMÉ. - Les Exocoetidae (Beloniformes) au nord-est du Brésil.

De mars 1994 à mai 1998, 1652 Exocoetidae ont été récoltés dans la zone comprise entre 2°N et 14°S, et entre 28°W et 41°W, par des navires de recherche et par des bateaux de pêche artisanale, dans le cadre du projet REVIZEE (Programme pour l'Évaluation de la Zone Économique Exclusive Brésilienne). Onze espèces ont été identifiées: *Cypselurus comatus*, *C. cyanopterus*, *C. exiliens*, *C. heterurus*, *C. melanurus*, *Exocoetus volitans*, *Hirundichthys affinis*, *H. speculiger*, *Oxyporhamphus micropterus similis*, *Parexocoetus brachypterus* et *Prognichthys gibbifrons*. *C. cyanopterus* et *H. affinis* sont très abondantes dans la région. La première, autour de l'Archipel São Pedro e São Paulo, est utilisée comme appât pour la pêche au thon. La seconde est le produit principal de la pêche artisanale dans l'état du Rio Grande do Norte. Elles étaient les espèces cibles du projet REVIZEE, compte tenu de leur importance comme ressource potentielle et comme constituant de la chaîne alimentaire épipélagique.

Key-words. - Exocoetidae, ASW, North-eastern Brazil, Geographical distribution.

Flyingfishes are tropical and subtropical world-wide distributed species. They make up an essential part of the epipelagic food chain, preyed by large pelagic fishes like tunas, sailfishes, sharks, billfishes, dolphinfish, among others. Many species have commercial importance as an important fishery resource in many countries: Indonesia, Pacific Islands, Philippines, Vietnam, Korea, China, Japan Sea, Southern Carolina (USA), West Africa, South-eastern and South India, Netherlands Antilles, eastern Caribbean and in the North-eastern Brazil (Parin, 1960; Cruz, 1965; Barroso, 1968; Gibbs, 1978; Dalzel, 1993; Parin and Lakshminarayanan, 1993; Mahon *et al.*, unpubl. data). In the

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south-eastern Caribbean where *H. affinis* is the main landed species, it may account for approximately 70% of the total annual catch (Mahon *et al.*, unpubl. data). In the State of Rio Grande do Norte, in the North-eastern Brazil, it is an important resource in artisanal fishery. It is often the second species landed in weight (IBAMA, unpubl. data).

There is some divergence related to flyingfish taxonomy. According to Bruun (1935) and Breder (1938) there are 8 genera in the Atlantic Ocean: *Cypselurus*, *Danichthys*, *Exocoetus*, *Fodiator*, *Hirundichthys*, *Oxyporhamphus*, *Parexocoetus*, *Prognichthys* and although they do not agree concerning the species of the genus *Cypselurus*. In the south-eastern Brazilian coast, Figueiredo and Menezes (1978) considered as Exocoetidae the following genus: *Hemiramphus*, *Hyporhamphus*, *Parexocoetus*, *Exocoetus*, *Cypselurus* and *Hirundichthys*. According to Nelson (1994) and to Smith and Heemstra (1986) *Oxyporhamphus* is included in family Hemiramphidae. However, the most recent work on flyingfish taxonomy (Dalsilao *et al.*, 1997) reintegrated this genus into the family Exocoetidae based on osteological and myological analysis of the caudal complex. We consider *O. micropterus similis* as an Exocoetidae and we used mainly Bruun (1935), Breder (1938) and Staiger (1965) identification keys.

The most abundant species of flyingfish in north-eastern Brazil are *Cypselurus cyanopterus* and *Hirundichthys affinis*. There is a considerable concentration of *C. cyanopterus* around the Archipelago of São Pedro e São Paulo (00°55'N and 29°21'W) from November to April, being caught by handline tuna vessels and used as bait for yellowfin tuna (*Thunnus albacares*) fishery. This species is also occasionally caught in drift nets targeting for hemiramphids (halfbeaks) off Caiçara (State of Rio Grande do Norte), but only in small amounts.

A survey of *C. cyanopterus* carried out by Barros and Morais (1968) on the shelf break of the States of Paraíba and Pernambuco (06°S to 09°S; 34°W to 35°W) indicated that this species occurs throughout the year. *C. cyanopterus* is the largest flyingfish species in the area (maximum length 42 cm TL), however, it is not exploited on a commercial basis.

Hirundichthys affinis is exploited by the artisanal fisheries in the state of Rio Grande do Norte (RN). Using a scoop net locally called "jerere" and gillnet the fishery takes place 110 km around Caiçara, which is the principal landing point in the region (Fig. 1). The main landing peak is between April and July and another smaller one between November and February (Monte, 1965). Catches are made up of only adults with more than 22 cm of total length (Barroso, 1967).

Despite the abundance of *C. cyanopterus* and *H. affinis* in the north-eastern Brazilian coast, there is no available information about other species occurring in the area. The main goal of this study is to report the occurrence and distribution of eleven flyingfishes species occasionally captured by research and commercial vessels in different locations in the study area between 1994 and 1998.

MATERIAL AND METHODS

Samples were collected between March 1994 and May 1998 by fishery boats and research vessels in the north-eastern Brazil. The study area (Fig. 1) corresponds to that of REVIZEE - NE Project (Brazilian Economic Exclusive Zone Assessment Program) between 02° N and 14° S and from 28° W to 41° W. Adults were collected by scoop net and frequently when they jumped into the boat, only *Hirundichthys affinis* was caught by gillnet, by

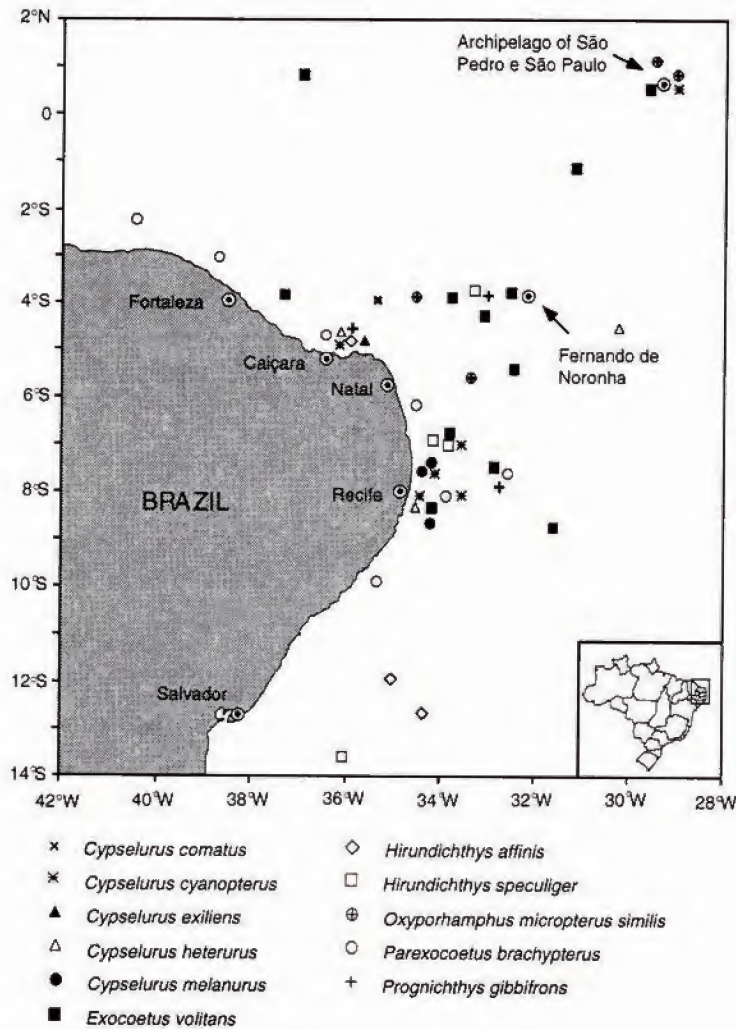


Fig. 1. - Distribution of flyingfish species identified off the northeast of Brazil.

artisanal boats in Caçara (RN). Juveniles were captured mostly in research cruises by scoop net, and accidentally by bongo and neuston net. Each individual was identified according to the previous studies (Bruun, 1935; Breder, 1938; Staiger, 1965; Gibbs, 1978) and the following measurements were made: total length (TL), fork length (FL) and standard length (SL). Important features for flyingfish identification are: position of dorsal and anal fins, position and size of pelvic fins, size and pigmentation of dorsal fin, number of predorsal scales, number of unbranched rays, barbels in the lower jaw and presence or absence of palatine teeth.

Table I. - Number of individuals, size range and position for each species collected. *: position not registered.

Species	N	Size range (cm)	Latitude	Longitude	Previous records in the study area
<i>Cypselurus comatus</i>	1	14.5	03°56'S	35°30'W	yes
	6	16.5-20.7	*	*	
<i>C. cyanopterus</i>	631	23.4-33.5	00°48'N	29°07'W	yes
	12	27.3-30.3	08°08'S	34°06'W	
	5	27.5-29.9	08°00'S	34°00'W	
	1	28.4	07°23'S	34°29'W	
	1	32.0	06°53'S	34°01'W	
	1	28.4	04°56'S	36°45'W	
<i>C. heterurus</i>	1	4.7	*	*	yes
	1	4.5	04°39'S	36°57'W	
	1	5.2	04°30'S	30°30'W	
	2	1.6-4.6	08°10'S	34°52'W	
<i>C. melanurus</i>	2	22.0-22.4	07°23'S	34°29'W	yes
	1	21.2	08°25'S	34°35'W	
	2	23	07°28'S	34°32'W	
	2	21.2-22.5	*	*	
<i>C. exiliens</i>	1	5.7	05°09'S	36°15'W	yes
<i>Exocoetus volitans</i>	2	2.4-18.2	04°16'S	33°13'W	yes
	1	5.3	03°52'S	33°54'W	
	1	2.9	03°45'S	32°44'W	
	2	3.4-5.3	07°20'S	33°31'W	
	1	2.7	06°53'S	34°01'W	
	52	2.0-4.1	00°42'N	29°40'W	
	1	2.6	05°22'S	32°32'W	
	1	2.1	03°48'S	37°35'W	
	3	2.8-3.4	00°48'S	36°58'W	
	2	6.0-6.8	08°08'S	34°35'W	
	1	6.0	01°02'S	31°16'W	
	1	3.9	08°47'S	31°37'W	
	11	2.7-17.2	*	*	
<i>Hirundichthys affinis</i>	1	5.8	12°30'S	34°27'W	yes
	1	5.4	12°04'S	35°09'W	
	851	17.3-24.2	05°00'S	36°29'W	
<i>H. speculiger</i>	1	7.7	07°00'S	34°12'W	yes
	1	21.7	06°53'S	34°01'W	
	1	21.3	13°32'S	36°07'W	
	1	10.75	03°41'S	33°17'W	
	2	7.3-22.5	*	*	
<i>Oxyorhamphus micropterus</i>	2	10.1 - 14.2	03°50'S	34°43'W	no
	1	13.5	01°15'N	29°39'W	
	1	13.3	00°57'N	29°05'W	
	1	11.1	05°35'S	33°26'W	
	4	12.2-14.5	*	*	
<i>Parexocoetus brachypterus</i>	4	9.4-11.4	04°39'S	36°32'W	yes
	3	10.9-11.3	06°21'S	34°44'W	
	1	11.7	07°30'S	33°00'W	
	5	10.9-11.3	02°59'S	38°46'W	
	2	10.8-11.0	08°20'S	34°38'W	
	4	7.4-8.0	02°06'S	40°31'W	
	1	9.7	09°53'S	35°28'W	
	11	9.9-11.4	*	*	
<i>Prognichthys gibbifrons</i>	1	16.1	04°45'S	36°36'W	no
	1	16.8	03°41'S	33°17'W	
	1	2.25	07°43'S	33°11'W	

RESULTS

We have collected 1652 specimens of flyingfish in the study area and, according to the features mentioned above, we have identified up to now eleven species, whose distributions are shown in figure 1.

Cypselurus comatus (Mitchill, 1815)

Seven specimens were analysed (Table I).

Remarks. - The main features for the identification of the genus *Cypselurus* are the position of the origin of dorsal fin anterior to the origin of anal fin, and only first pectoral ray unbranched. Number of predorsal scales between 26 and 28 and weak palatine teeth. A juvenile character is a single barbel in the lower jaw (Breder, 1938), which was observed in the juvenile collected, corresponding to 39% of SL.

Distribution. - Atlantic Ocean (Bruun, 1935), Tropical Atlantic (Nesterov and Grundtsev, 1981), eastern Atlantic (Breder, 1938), Gulf Stream and Bahamas (Staiger, 1965).

Cypselurus cyanopterus (Valenciennes, 1846)

651 adults were collected, most of them from the Archipelago of São Pedro e São Paulo (Table I).

Remarks. - According to Staiger (1965) the main juvenile characteristic is a pair of mandibular barbels. Adults have pigmented dorsal-fin, caudal-fin and pectoral-fins darkly pigmented. Low number of vertebrae (43-46), between 30 and 41 predorsal scales and strong palatine teeth. Bruun (1935) recorded a maximum size of 33.3 cm SL, while we have observed individuals with 38.1 cm SL.

Distribution. - Atlantic Ocean (Bruun, 1935), eastern Atlantic (Breder, 1938; Gibbs and Staiger, 1970), in the Atlantic, occidental side from south-eastern USA to Rio de Janeiro (Figueiredo and Menezes, 1978); eastern Caribbean (Oxenford *et al.*, 1995), Gulf of Mexico, Gulf Stream and Caribbean Sea (Staiger, 1965); in Brazil: shelf break of Pernambuco and Paraíba (Barros and Morais, 1968), São Pedro e São Paulo Rocks (Vaske Jr. *et al.*, unpubl. data).

Cypselurus heterurus (Mitchill, 1815)

Five juveniles were examined (Table I).

Remarks. - Juveniles were identified according to the key for individuals smaller than 10 cm of Staiger (1965): six vertical pigmented bars along the body, paired short barbels, less than 5% SL and size of first pectoral ray less than 38%.

Distribution. - Atlantic Ocean, in the western side from 42°N to 23°S, and in the eastern side from 59°S to 4°N, common in the Caribbean Sea and in the Gulf of Mexico (Staiger, 1965). Bruun (1935) has reported it in Oslo Fjord (North Atlantic) and Gibbs (1978) in the Mediterranean Sea.

Cypselurus melanurus (Rafinesque, 1810)

Five adults from the shelf break between Pernambuco and Rio Grande do Norte (Table I).

Remarks. - Main features for adult identification were: number of predorsal scales between 28-32, lack of palatine teeth, dorsal fin lightly or not pigmented, pectoral fins lightly pigmented with a paler basal triangle (Gibbs, 1978).

Distribution. - Eastern Tropical Atlantic from 15°N to 5°N and in western Atlantic from 40°N to 25°S (Staiger, 1965).

***Cypselurus exiliens* (Linné, 1771)**

One juvenile was collected in the shelf break of Caiçara (Table I).

Remarks. - There is a dark spot on dorsal fin and pectoral fins are dark, with an obvious pale crossband (Gibbs, 1978), predorsal scales between 21 and 30 (Breder, 1938).

Distribution. - Western central Atlantic Ocean, in the Caribbean Sea, Gulf of Mexico and Gulf Stream (Staiger, 1965), and in South Atlantic as far south as Rio de Janeiro (Figueiredo and Menezes, 1978).

***Exocoetus volitans* (Linnaeus, 1758)**

Seventy nine specimens analysed, mostly juveniles (Table I).

Remarks. - A distinctive character is the short size of pelvic fins and their distance to anal fin (Figueiredo and Menezes, 1978).

Distribution. - Atlantic, Pacific and Indian oceans (Figueiredo and Menezes, 1978); Atlantic Ocean (Bruun, 1935; Grundtsev *et al.*, 1987); eastern Caribbean (Breder, 1938; Hunte *et al.*, 1995), in the south Atlantic Ocean until 25°S (Bruun, 1935).

***Hirundichthys affinis* (Gunther, 1866)**

853 individuals were captured (Table I), mostly from the artisanal fishery from Caiçara (RN).

Remarks. - Features for genus identification are that the dorsal and anal fins begin on the same vertical line, the first pectoral ray is simple and the second is bifurcate (Breder, 1938).

Distribution. - Atlantic Ocean (Bruun, 1935); tropical Atlantic (Nesterov and Grundtsev, 1981); eastern Caribbean (Breder, 1938; Evans, 1961; Mahon *et al.*, unpubl. data; Hunte *et al.*, 1995); north-eastern Brazil (Grangeiro, 1963; Almeida, 1966; Cruz and Soares, 1966; Barroso, 1967).

***Hirundichthys speculiger* (Valenciennes, 1846)**

Six individuals collected (Table I).

Remarks. - The ground colour of pectoral is dark gray with a broad unpigmented margin while *H. affinis* has a narrow unpigmented margin. Juvenile stages differs from adults both in form and colour (Bruun, 1935).

Distribution. - Atlantic Ocean (Bruun, 1935; Breder, 1938); in western Atlantic from Florida to south-eastern Brazil (Figueiredo and Menezes, 1978); Eastern Caribbean (Hunte *et al.*, 1995).

***Oxyporhamphus micropterus similis* (Bruun, 1935)**

Six individuals collected (Table I).

Remarks. - The main feature is a short pectoral fin, less than 40% of SL.

Distribution. - Western Atlantic, Caribbean Sea (Breder, 1938); Barbados, St. Lucia and eastern Caribbean (Bruun, 1935).

***Parexocoetus brachypterus* (Richardson, 1846)**

Thirty-one adults were collected between 2 and 10°S (Table I).

Remarks. - Pelvic fins are smaller than in the others species and dorsal fins are very large with a dark spot.

Distribution. - Atlantic and Pacific Ocean. In the western Atlantic is distributed from south-eastern USA to south-eastern Brazil (Figueiredo and Menezes, 1978); west Indian waters (Bruun, 1935), tropical Atlantic (Nesterov and Grundtsev, 1981); eastern Caribbean (Breder, 1938; Oxenford *et al.*, 1995; Hunte *et al.*, 1995).

***Prognichthys gibbifrons* (Cuvier & Valenciennes, 1846)**

Two adults and one juvenile were collected in the study area (Table I).

Remarks. - First two pectoral rays unbranched, while in *Hirundichthys* and *Cypselurus* only first ray is branched. *Danichthys* has the same character as *Prognichthys*, although the pectoral fin pigmentation is different.

Distribution. - Tropical and subtropical north Atlantic, Caribbean Sea and Gulf of Mexico (Gibbs, 1978).

DISCUSSION

Mostly of the individuals collected in this work are of the species more abundant in the study area, *Cypselurus cyanopterus* and *Hirundichthys affinis*. All the other species were occasionally captured during research and fishing cruises carried out in the study area.

C. comatus had already been recorded in the area, around 10°S (Bruun, 1935). In this work the species was caught in the oceanic banks of the northern Brazilian Chain.

C. cyanopterus is very abundant around the Archipelago of São Pedro e São Paulo during the period of tuna fishery, *i.e.*, between November and April. This area seems to be an important spawning ground for this species, taking into account the large number of mature individuals and high larval abundance observed in ichthyoplankton samples. Adult individuals of this species are the most important prey in stomach contents of yellowfin tuna (*Thunnus albacares*) and wahoo (*Acanthocybium solandri*) in nearby waters of the Archipelago of São Pedro e São Paulo (Vaske Jr. *et al.*, unpubl. data).

C. melanurus is a neritic species and it was already been recorded in the area, between 13° and 23°S (Staiger, 1965). Five adults were collected in the shelf break off Recife. *C. heterurus* is another coastal species (Staiger, 1965) and in this work there were observed only juveniles between 4° and 8°S.

Exocoetus volitans is an oceanic species and in the western Atlantic Ocean individuals were recorded between 33°S and 33°N (Bruun, 1935; Grundtsev *et al.*, 1986). The species was widespread in the study area, meanwhile 52 juveniles were collected near the Archipelago of São Pedro e São Paulo, in September. This could be also an important reproduction area for this species, as it is for *C. cyanopterus*.

For the genus *Hirundichthys*, Bruun (1935) pointed out that many individuals of *H. speculiger* were reported in the shelf break between 5°S and 15°S, and only one specimen of *H. affinis* in 2°S. In the present study all the individuals of *H. speculiger* were collected southern of 4°S, in the same area mentioned by Bruun (1935), while *H. affinis* was abundant northern to 5°S, in the state of Rio Grande do Norte. It is also abundant in the Eastern Caribbean (Hunte *et al.*, 1995).

It seems to be a change in the abundance of these species around 5°S, to the north *H. affinis* is abundant and to the south it seems that *H. speculiger* is more common. Fi-

gueiredo and Menezes (1978) have recorded *H. speculiger* and *H. rondeleti* in the south-eastern Brazil, but not *H. affinis*.

Six individuals of *Oxyporhamphus micropterus similis* were caught in the northern part of the study area, and two of them around the Archipelago of São Pedro e São Paulo. This species is an occasional prey of dolphinfish in north-eastern Brazil (Vaske Jr. et al., unpubl. data).

Parexocoetus brachypterus was collected in the study area between 2 and 10°S, generally in the shelf break. According to Figueiredo and Menezes (1978), the species is abundant in the open ocean.

Prognichthys gibbifrons is an oceanic form that Bruun (1935) mentions having never been taken between 18°N and 20°S. Three specimens were collected in the area, one off Caiçara, another in the oceanic area off Recife and the last one near Fernando de Noronha.

Six genera with 11 species have been identified up to now, and considering information gathered from literature other species are likely to be caught in the area.

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